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ARMORED FORCE MEDICAL RESEARCH LABORATORY

FORT KNOX, KENTUCKY

INDEXED

PROJECT NO. 3 - TOXIC GASES IN ARMORED VEHICLES

Final Report On

Sub-Project No. 3-2 - Determination of the Characteristics
and Effects Upon the Crew of Gun Fumes
from Firing of the Weapons in Tanks of
the M5 Series.

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Project No. 3-2

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April 26, 1943

ARMORED FORCE MEDICAL RESEARCH LABORATORY
Fort Knox, Kentucky

Project No. 3-2
724.2 GNOML

April 26, 1943

1. PROJECT: No. 3 - Toxic Gases in Armored Vehicles. Final Report on: Sub-Project No. 3-2, Determination of the Characteristics and Effects Upon the Crew of Gun Fumes from Firing of the Weapons in Tanks of the M5 Series.

a. Authority - Letter Commanding General, Headquarters Armored Force, Fort Knox, Kentucky, 400.112/6 GNOHD, dated September 24, 1942.

b. Purpose - To determine the extent of the hazard from fumes released by firing of the weapons in the M5A1 tank.

2. DISCUSSION:

a. Methods and Conditions.

(1) Fire Pattern:

(a) 37mm gun: The piece was fired at the rate of one round every 5 seconds in bursts of 10. One burst was fired every 5 minutes.

(b) Machine Guns: Three belts of 250 rounds each were fired from the turret machine gun in 19 minutes 20 seconds: four belts of 250 rounds each were fired from the bow machine gun in 24 minutes 5 seconds. The intervals between belts varied from 1 minute 20 seconds to 3 minutes 10 seconds.

(2) Ammunition: 37mm. A.P. M74 with tracer. Machine Gun: Caliber .30 ball.

(3) Tank operation: Tank buttoned-up, full crew in tank, and engine idling at 500 to 600 rpm. Tail wind 3 mph. In test 1, with the 37mm gun and in both machine gun trials, the bulkhead ports were closed and the bow ventilating fan was at full exhaust. Test 2, 37mm, bulkhead ports closed, fan off, Test 3, 37mm, bulkhead ports open, fan on full exhaust.

(4) Analysis: Details of the analytical procedures used were reported previously (Project 3-1, 3-5, February 15, 1943). Air samples were analyzed for carbon monoxide and ammonia. Air samples were not analyzed for nitrous fumes, earlier tests having indicated the absence of significant amounts.

3. CONCLUSIONS:

a. 37mm gun:

(1) Under all conditions tested the average air concentrations of carbon monoxide were well within the acceptable limits of 0.05%.

(2) The maximum accumulation of carbon monoxide in the blood of crew members during firing of the 37 mm gun was 3.4% which is of no practical significance.

(3) Carbon Monoxide concentrations were slightly higher when the bow ventilating fan was on exhaust than when it was not running.

(4) Ammonia concentrations did not reach troublesome levels. (less than 60 ppm).

b. Machine guns:

(1) The average concentrations of carbon monoxide were well within the acceptable limit of 0.05% in the case of the turret machine gun and just within that limit (0.046%) in the case of the bow machine gun.

(2) Insignificant amounts of carbon monoxide accumulated in the blood of the crew members during firing of both machine guns.

c. Control of gun fumes in the M5A1 is at present adequate.

4. RECOMMENDATIONS:

a. Present ventilation of the M5A1 be considered adequate for control of gun fumes.

b. This tank should not be fired with the tank engine dead and the hatches closed.

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1 - Appendix

2 - Tables 1, 2, 3

RESULTS.

1. 37mm gun: A complete trial was carried out in test 1. Six bursts were fired, blood samples were taken and the standard series of continuous and instantaneous air samples were collected. In tests 2 and 3 only 2 bursts were fired and sampling was limited to snap samples and use of the Mine Safety Appliance (MSA) CO indicator. In all cases exposure to both ammonia and carbon monoxide was well within safe limits. Table 1 gives the resulting concentrations of carbon monoxide. Table 3 records carbon monoxide concentrations in the bloods taken from the crew members; insignificant increases were found. Only small amounts of ammonia were found in the air samples taken at the loader's position at the end of the bursts, ranging from 20 to 60 ppm. No complaints were made by the crew members of irritation by ammonia.

2. Machine guns: As judged by these trials ventilation at the turret machine gun is better in the M5A1 than at the bow machine gun. Thus the average concentration of carbon monoxide by continuous sample at the gunner's position during firing of the turret gun was 0.012%, while the air at the breathing zone of the assistant driver during firing of the bow gun averaged 0.046%. See table 2. Corroborating results were secured by the MSA indicator (not shown). Also the ammonia concentration in instantaneous samples taken at the same positions ranged from 40 to 65 ppm at the bow gun while at the turret gun, values of from 20 to 40 ppm were found. In neither case is any hazard likely to be present during these conditions of firing.

TABLE 1

CONCENTRATIONS OF CARBON MONOXIDE FROM 37 MM GUN

Ventilation		Carbon Monoxide Percent
Test 1 Bow Fan on Full Exhaust Bulkhead Ports Closed Engine Idling	Peak Concentration at End of Burst	
	After 1st Burst	0.029
	" 2nd "	0.050
	" 3rd "	0.121
	" 4th "	0.046
	" 5th "	0.062
	" 6th "	0.048
	Average Concentration	
	Loader, by Continuous Sampling	0.017
	Loader, by MSA	0.021
Test 2 Bow Fan Off Bulkhead Ports Closed Engine Idling	Asst. Driver, by Continuous Sampling	0.009
	Clearance Rate after last Burst (Time for Conc. to decrease 50%)	14 Seconds
Test 3 Bow Fan On Full Exhaust Bulkhead Ports Open Engine Idling	Peak Concentration After 2nd Burst	0.033
	Average Concentration Loader, by MSA	0.009
	Peak Concentration After 2nd Burst	0.041
	Average Concentration Loader, by MSA	0.010

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TABLE 2

CONCENTRATIONS OF CARBON MONOXIDE FROM BOW
AND TURRET MACHINE GUNS

	CARBON MONOXIDE PERCENT
TURRET MACHINE GUN	
Peak Concentration at end of Belt (Loader) After 1st Belt	0.033
" 2nd "	0.033
" 3rd "	0.017
Average Concentration by Continuous Sampling Gunner	0.012
Assistant Driver	0.016
BOW MACHINE GUN	
Peak Concentration at end of Belt (Asst. Driver) After 1st Belt	0.032
" 2nd "	0.024
" 4th "	0.029
Average Concentration By Continuous Sampling Asst. Driver (Gunner)	0.046
Driver	0.009
Loader	0.013

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TABLE 3

CARBON MONOXIDE CONCENTRATIONS IN BLOOD OF CREW MEMBERS

Crew Member	CO Hemoglobin as % of Total		
	Before Exposure	After Exposure	Increase
37 Mm Gun			
Loader	3.8	7.2	3.4
Gunner	0.2	2.0	1.8
Driver	---	3.3	---
Asst. Driver	0.5	0.8	0.3
Turret Machine Gun			
Loader	5.1	5.1	0.0
Gunner	4.7	4.5	0.0
Asst. Driver	3.8	6.1	2.3
Bow Machine Gun			
Asst. Driver	6.1	8.2	2.1
Driver	---	2.6	---
Loader	2.2	2.2	0.0

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TABLE 1			
1950	1951	1952	1953
1954	1955	1956	1957
TABLE 2			
1958	1959	1960	1961
1962	1963	1964	1965
TABLE 3			
1966	1967	1968	1969
1970	1971	1972	1973
TABLE 4			
1974	1975	1976	1977
1978	1979	1980	1981
TABLE 5			
1982	1983	1984	1985
1986	1987	1988	1989
1990	1991	1992	1993
TABLE 6			
1994	1995	1996	1997
1998	1999	2000	2001
TABLE 7			
2002	2003	2004	2005
2006	2007	2008	2009
2010	2011	2012	2013
TABLE 8			
2014	2015	2016	2017
2018	2019	2020	2021
TABLE 9			
2022	2023	2024	2025
2026	2027	2028	2029
2030	2031	2032	2033
TABLE 10			
2034	2035	2036	2037
2038	2039	2040	2041
2042	2043	2044	2045
2046	2047	2048	2049
2050	2051	2052	2053
TABLE 11			
2054	2055	2056	2057
2058	2059	2060	2061
2062	2063	2064	2065
2066	2067	2068	2069
2070	2071	2072	2073
TABLE 12			
2074	2075	2076	2077
2078	2079	2080	2081
2082	2083	2084	2085
2086	2087	2088	2089
2090	2091	2092	2093
TABLE 13			
2094	2095	2096	2097
2098	2099	2100	2101
2102	2103	2104	2105
2106	2107	2108	2109
2110	2111	2112	2113
TABLE 14			
2114	2115	2116	2117
2118	2119	2120	2121
2122	2123	2124	2125
2126	2127	2128	2129
2130	2131	2132	2133
TABLE 15			
2134	2135	2136	2137
2138	2139	2140	2141
2142	2143	2144	2145
2146	2147	2148	2149
2150	2151	2152	2153
TABLE 16			
2154	2155	2156	2157
2158	2159	2160	2161
2162	2163	2164	2165
2166	2167	2168	2169
2170	2171	2172	2173
TABLE 17			
2174	2175	2176	2177
2178	2179	2180	2181
2182	2183	2184	2185
2186	2187	2188	2189
2190	2191	2192	2193
TABLE 18			
2194	2195	2196	2197
2198	2199	2200	2201
2202	2203	2204	2205
2206	2207	2208	2209
2210	2211	2212	2213
TABLE 19			
2214	2215	2216	2217
2218	2219	2220	2221
2222	2223	2224	2225
2226	2227	2228	2229
2230	2231	2232	2233
TABLE 20			
2234	2235	2236	2237
2238	2239	2240	2241
2242	2243	2244	2245
2246	2247	2248	2249
2250	2251	2252	2253
TABLE 21			
2254	2255	2256	2257
2258	2259	2260	2261
2262	2263	2264	2265
2266	2267	2268	2269
2270	2271	2272	2273
TABLE 22			
2274	2275	2276	2277
2278	2279	2280	2281
2282	2283	2284	2285
2286	2287	2288	2289
2290	2291	2292	2293
TABLE 23			
2294	2295	2296	2297
2298	2299	2300	2301
2302	2303	2304	2305
2306	2307	2308	2309
2310	2311	2312	2313
TABLE 24			
2314	2315	2316	2317
2318	2319	2320	2321
2322	2323	2324	2325
2326	2327	2328	2329
2330	2331	2332	2333
TABLE 25			
2334	2335	2336	2337
2338	2339	2340	2341
2342	2343	2344	2345
2346	2347	2348	2349
2350	2351	2352	2353
TABLE 26			
2354	2355	2356	2357
2358	2359	2360	2361
2362	2363	2364	2365
2366	2367	2368	2369
2370	2371	2372	2373
TABLE 27			
2374	2375	2376	2377
2378	2379	2380	2381
2382	2383	2384	2385
2386	2387	2388	2389
2390	2391	2392	2393
TABLE 28			
2394	2395	2396	2397
2398	2399	2400	2401
2402	2403	2404	2405
2406	2407	2408	2409
2410	2411	2412	2413
TABLE 29			
2414	2415	2416	2417
2418	2419	2420	2421
2422	2423	2424	2425
2426	2427	2428	2429
2430	2431	2432	2433
TABLE 30			
2434	2435	2436	2437
2438	2439	2440	2441
2442	2443	2444	2445
2446	2447	2448	2449
2450	2451	2452	2453
TABLE 31			
2454	2455	2456	2457
2458	2459	2460	2461
2462	2463	2464	2465
2466	2467	2468	2469
2470	2471	2472	2473
TABLE 32			
2474	2475	2476	2477
2478	2479	2480	2481
2482	2483	2484	2485
2486	2487	2488	2489
2490	2491	2492	2493
TABLE 33			
2494	2495	2496	2497
2498	2499	2500	2501
2502	2503	2504	2505
2506	2507	2508	2509
2510	2511	2512	2513
TABLE 34			
2514	2515	2516	2517
2518	2519	2520	2521
2522	2523	2524	2525
2526	2527	2528	2529
2530	2531	2532	2533
TABLE 35			
2534	2535	2536	2537
2538	2539	2540	2541
2542	2543	2544	2545
2546	2547	2548	2549
2550	2551	2552	2553
TABLE 36			
2554	2555	2556	2557
2558	2559	2560	2561
2562	2563	2564	2565
2566	2567	2568	2569
2570	2571	2572	2573
TABLE 37			
2574	2575	2576	2577
2578	2579	2580	2581
2582	2583	2584	2585
2586	2587	2588	2589
2590	2591	2592	2593
TABLE 38			
2594	2595	2596	2597
2598	2599	2600	2601
2602	2603	2604	2605
2606	2607	2608	2609
2610	2611	2612	2613
TABLE 39			
2614	2615	2616	2617
2618	2619	2620	2621
2622	2623	2624	2625
2626	2627	2628	2629
2630	2631	2632	2633
TABLE 40			
2634	2635	2636	2637
2638	2639	2640	2641
2642	2643	2644	2645
2646	2647	2648	2649
2650	2651	2652	2653
TABLE 41			
2654	2655	2656	2657
2658	2659	2660	2661
2662	2663	2664	2665
2666	2667	2668	2669
2670	2671	2672	2673
TABLE 42			
2674	2675	2676	2677
2678	2679	2680	2681
2682	2683	2684	2685
2686	2687	2688	2689
2690	2691	2692	2693
TABLE 43			
2694	2695	2696	2697
2698	2699	2700	2701
2702	2703	2704	2705
2706	2707	2708	2709
2710	2711	2712	2713
TABLE 44			
2714	2715	2716	2717
2718	2719	2720	2721
2722	2723	2724	2725
2726	2727	2728	2729
2730	2731	2732	2733
TABLE 45			
2734	2735	2736	2737
2738	2739	2740	2741
2742	2743	2744	2745
2746	2747	2748	2749
2750	2751	2752	2753
TABLE 46			
2754	2755	2756	2757
2758	2759	2760	2761
2762	2763	2764	2765
2766	2767	2768	2769
2770	2771	2772	2773
TABLE 47			
2774	2775	2776	2777
2778	2779	2780	2781
2782	2783	2784	2785
2786	2787	2788	2789
2790	2791	2792	2793
TABLE 48			
2794	2795	2796	2797
2798	2799	2800	2801
2802	2803	2804	2805
2806	2807	2808	2809
2810	2811	2812	2813
TABLE 49			
2814	2815	2816	2817
2818	2819	2820	2821
2822	2823	2824	2825
2826	2827	2828	2829
2830	2831	2832	2833
TABLE 50			
2834	2835	2836	2837
2838	2839	2840	2841
2842	2843	2844	2845
2846	2847	2848	2849
2850	2851	2852	2853
TABLE 51			
2854	2855	2856	2857
2858	2859	2860	2861
2862	2863	2864	2865
2866	2867	2868	2869
2870	2871	2872	2873
TABLE 52			
2874	2875	2876	2877
2878	2879	2880	2881
2882	2883	2884	2885
2886	2887	2888	2889
2890	2891	2892	2893
TABLE 53			
2894	2895	2896	2897
2898	2899	2900	2901
2902	2903	2904	2905
2906	2907	2908	2909
2910	2911	2912	2913
TABLE 54			
2914	29		